REMARKS

This amendment is responsive to the Office Action mailed July 20, 2006. Claims 2-5, 7-10, 12-18, and 39-41 are pending in the application. Independent Claim 39 and its dependent Claims 12-18 have been allowed. Claims 2-5, 7-10, 40, and 41 were rejected under 35 U.S.C. § 112 (written description). By this paper, independent Claim 40 has been amended. No new claims have been added.

Independent Claim 40 Complies With The Written Description Requirement And Is Patentable Over The Prior Art

Claim 40 has been amended to be more explicit in reciting the manner in which the error bound is minimized. As will be discussed below, the subject matter claimed in Claim 40 has been described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventors had possession of the invention at the time the application was filed.

Claim 40 reads as follows:

> 40. A method for generating a first plurality of output data values by transforming a plurality of input data values using a computer, the first plurality of output data values approximating a second plurality of output data values, the second plurality of output data values generated by applying a linear transform to the plurality of input data values, the linear transform comprising a 2x2 diagonal matrix D of determinant 1, the method comprising at least one step of the following types:
>
> rearranging at least one data value in a plurality of current input data values;
>
> negating at least one data value in the plurality of current input data values;
>
> modifying at least one data value in the plurality of current input data values, each modified data value generated by applying a linear combination of unmodified values in the plurality of input data values to the at least one data value, the linear combination comprised of an integer generated in a reproducible manner, and
>
> a step that is equivalent to a successive combination of one or more of the preceding three types;

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wherein an error difference between the first plurality of output data values and the second plurality of output data values is bounded, the method further comprising factoring D into four elementary matrices

$$D = \begin{pmatrix} 1 & r \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ s & 1 \end{pmatrix} \begin{pmatrix} 1 & -r\alpha^{-1} \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -s\alpha & 1 \end{pmatrix}, \text{ where rs +1 = } \alpha\text{; or}$$

$$D = \begin{pmatrix} 1 & 0 \\ s & 1 \end{pmatrix} \begin{pmatrix} 1 & r \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -s\alpha & 1 \end{pmatrix} \begin{pmatrix} 1 & -r\alpha^{-1} \\ 0 & 1 \end{pmatrix}, \text{ where rs + 1 = } \alpha^{-1}\text{; or}$$

factoring D into three elementary matrices and a permutation matrix

$$D = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \alpha & 1 \end{pmatrix} \begin{pmatrix} 1 & -\alpha^{-1} \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \alpha & 1 \end{pmatrix}; \text{ or}$$

$$D = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 & \alpha^{-1} \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -\alpha & 1 \end{pmatrix} \begin{pmatrix} 1 & \alpha^{-1} \\ 0 & 1 \end{pmatrix}; \text{ and}$$

selecting a value for α and, if necessary, determining a value for r, to minimize the bound of the error difference for at least one of the preceding factorizations.

As indicated in the Introduction (pages 5 to 6), the present application describes methods for approximating a linear transformation and providing a bounded error reversible transformation.

The present application undertakes a matrix factorization process that leads to a bounded approximation error whose error bound is minimized. Page 6, lines 11-14, describes an underlying "divide and conquer" approach using matrix factorization:

> The main approach we will use for integer approximations is to divide and conquer: if we have a linear transformation with no obvious suitable integer approximation, then we factor the matrix into parts which we do know how to approximate. The composition of these approximations of parts will be a suitable approximation to the entire transformation.

At page 9, line 17 to page 16, line 23, the present application describes in detail a method for optimizing the error bound over a set of factorizations for a diagonal matrix of determinant 1.

It should be understood that finding transformations with optimal error bounds does not necessarily imply finding the absolute best transformation. Instead, Claim 40 recites selecting a

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value for variable "α" and, if necessary, determining a value for variable "r", to minimize the bound of the error difference for at least one of four defined factorizations. In particular, the specification (page 10) sets forth four factorizations of a diagonal transform, each of which depends on a selected parameter "α." The prior art has not contemplated the bound on the error nor attempted to minimize the error bound for such factorizations.

By selecting a parameter "α" and if necessary, determining a parameter "r", for one or more of the four factorizations, a minimized error bound is achieved among a certain class of transformations. As described, for each transformation, values can be chosen such that an error bound is guaranteed. Then, if one has a transformation that needs to be approximated, the application describes choosing an approximation that has a minimal error bound from among the four classes described on page 10 and claimed in Claim 40. (See, e.g., the conclusion at page 16, lines 13-14.) This does not say that an optimal solution has been found in the absolute sense; rather, the methods in the present application are concerned with optimizing an *error bound.* In other words, the application optimizes the bounds and not the actual error to find approximations in which the error bound is minimized.

For example, the present application does not rule out the possibility that one could factor a diagonal matrix into 437 matrices and get an approximation that has a smaller error. But one would not want to do that because it would be very expensive to compute the approximation. There are other considerations besides the size of the error. The present application considers some specific factorizations with a small number of factors and then shows how to find ones with computable error bounds. The application also shows that once one has thought of measuring error, that the prior art does not have as good of error bounds as the ones that produced according to the present application.

For factorization 2.1 (page 10, line 6), the present application describes an error bound "d" at page 15, line 1, and further describes, on page 15, lines 13-19:

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Again consider the example $\alpha = \sqrt{2}$. For (2.1) we have a single error formula and can proceed directly to numerical optimization to find that the best value for r is about 0.5789965414556075, giving an error bound of about 1.9253467944884184. For (2.2), the error bound is the maximum of four separate formulas; it turns out that this is minimized where two of the formulas cross each other, at $r = \sqrt{2\sqrt{2}-2}/2 \approx 0.4550898605622273$, and the error bound is $\sqrt{12+18\sqrt{2}}/4 \approx 1.5300294956861884$.

Consider the following analogy. Suppose a person is building a jet engine and desires to design an engine that has low fuel consumption. Given a required amount of thrust, the person produces a collection of designs that have the required thrust and further produces a method for bounding the fuel consumption of all the designs in the collection. The designs do not include all possible designs but are characterized by the fact that they all have less than 5000 parts. (The collection of designs might not even be all designs with less than 5000 parts but just be all the designs the person could think of at the time with less than 5000 parts). This process of designing engines in which fuel consumption is bounded and optimized is extremely useful. After all, it is very expensive to just build one of the engines and test it. The person still has to build the chosen engine to determine its actual fuel consumption but the person knows it is going to be less than the computed bound. This process of designing engines in which the fuel consumption for a collection of designs is bounded and the bound is optimized is analogous to the process described in the present application in which error bounds for a collection of factorizations is determined and optimized.

The Office Action cited Gormish at page 63, Equation 1 and page 64, Equations 2-4 as anticipating Claim 40. Neither these equations nor the corresponding description in Gormish suggest an error bound that is minimized as claimed in Claim 40.

Gormish has shown a form of transformation but does not teach anything about diagonal transformations which are the most difficult to approximate. Debauchies has shown that a wavelet can be factored but does not discuss error bounding. The present application reduces the

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difficulties in finding a bounded error reversible transformation when using a diagonal transformation of determinant 1. The application shows that the error bound for an approximated transformation can be found from the bounds on the factors.

Applicants submit that Claim 40 is patentable over Gormish et al. Moreover, the articles by Daubechies et al. and Li et al. do not overcome the deficiencies discussed above with respect to Gormish et al. Accordingly, Claim 40 should be allowed.

Dependent Claims 2-5, 7-10, and 41 Are In Allowable Condition

Dependent Claims 2-5, 7-10, and 41 are also patentable for their dependence on an allowable base claim and for the additional subject matter they recite.

CONCLUSION

For at least the foregoing reasons, applicants submit that the pending claims are all in condition for allowance. Action to that end is requested. Should any issues remain prior to allowance, the Examiner is invited to contact the undersigned attorney by telephone.

Respectfully submitted,

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